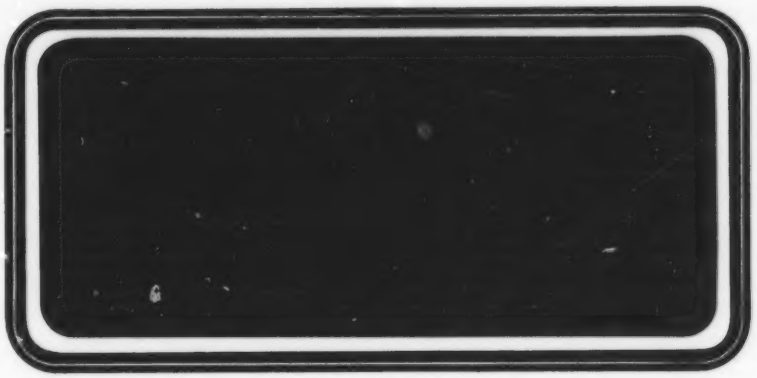
Canada Alberta

FOREST RESOURCE DEVELOPMENT AGREEMENT
ENTENTE SUR LA MISE EN VALEUR DES RESSOURCES FORESTIERES



Canada Alberta

The Canada–Alberta Forest Resource Development Agreement is a subsidiary agreement of the Canada–Alberta Economic and Regional Development Agreement, which provides coordination and cooperation between the governments of Alberta and Canada in areas of Alberta's economic development.

The Canada–Alberta Forest Resource Development Agreement is funded equally by the governments of Canada and Alberta, from April 1, 1984, to March 31, 1989.

Its primary objectives are to ensure the long-term availability of timber supplies; to optimize timber uses; and to contribute to the growth and diversification of Alberta's economy.

The Agreement comprises three programs: Reforestation; Applied research, technology transfer and opportunity identification; and Public information, evaluation and administration. These programs are managed by a joint Directorate and are implemented by Forestry Canada and the Alberta Forest Service.

L'Entente Canada–Alberta sur la mise en valeur des ressources forestières est auxiliaire à l'Entente Canada–Alberta sur le développement économique et régional, qui vise à assurer la coordination et la coopération des deux gouvernements relativement au développement économique de l'Alberta.

L'Entente Canada–Alberta sur la mise en valeur des ressources forestières est financée à parts égales par les gouvernements du Canada et de l'Alberta, et a cours du 1er avril 1984 au 31 mars 1989.

Ses objectifs principaux sont assurer la disponibilité à long terme de réserves de bois; optimiser leur utilisation; et contribuer à la croissance et la diversification de l'économie de la province.

L'Entente comprend trois programmes: Reboisement; Recherche appliquée, transferts de connaissances techniques et relevé des occasions; et Information, évaluation et administration. Ces programmes sont gérés par un Bureau de direction conjoint, et mis en oeuvre par Forêts Canada et le Service forestier de l'Alberta.

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Tree Improvement Applied Research and Technology Transfer

Alberta Forest Service
Genetics and Tree Improvement Section
Reforestation Branch[1]

1990

This is a joint publication of Forestry Canada
and the Alberta Forest Service pursuant to the
Canada-Alberta Forest Resource Development Agreement

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Project # 1433-95

FINAL PROGRESS REPORT

TREE IMPROVEMENT APPLIED RESEARCH AND TECHNOLOGY TRANSFER

Alberta Forest Service*
1990

Genetics and Tree Improvement Section
Reforestation Branch

This is a joint publication of the Canadian Forestry Service and the Alberta Forest Service pursuant to the Canada/Alberta Forest Resource Agreement.

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DISCLAIMER

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The views, conclusions and recommendations are those of the authors. The exclusion of certain manufactured products does not necessarily imply disapproval nor does the mention of other products necessarily imply endorsement by Forestry Canada or the Alberta Forest Service.

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ABSTRACT

The C.A.F.R.D.A. (Canada-Alberta Forest Resource Development Agreement) tree improvement project was started in April 1986 with a four year term. The objective of the project was to expand and accelerate work on the provincial genetics and tree improvement program in order to enhance yield, wood quality and pest resistance of future forest plantings in Alberta. This report provides a description of project activities and accomplishments during the term of the project. Only the increased portion of the work accomplished on the provincial genetics and tree improvement program due to C.A.F.R.D.A. funding is described. This work included: (1) field selection and wood quality evaluations of 99 superior trees for two genetic improvement projects; (2) establishment of 20 new research plantations on species, provenance and genetic testing topics, and carrying out intensive investigations on three flowering and seed production studies; (3) planning and implementing a rare and exceptional stands survey; (4) site developments for nine new experimental areas; (5) a substantially increased plant propagation, seed technology and technical support program to meet requirements of the expanded tree improvement program. The report also presents a summary of selected research results to highlight some interesting and noteworthy findings.

ACKNOWLEDGEMENTS

The work described in this report is collective effort of many individuals. Although almost all the work described here was carried out by the Alberta Forest Service staff, significant assistance was provided by the Alberta Department of Agriculture and B.C. Ministry of Forests and Lands which is gratefully acknowledged. Sincere appreciation and credit is due following staff of the Alberta Forest Service for their contributions to the project:

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1.0 BACKGROUND

Work on the provincial tree improvement program in Alberta was started in 1976 by the Alberta Forest Service as part of an overall plan to move towards intensive forest management in order to enhance yield and quality of the future forest. It is well established that the yield, hardiness and wood quality of forest trees can be substantially increased by developing genetically superior strains of seed and their use in reforestation. Large practical benefits are already being realized in many parts of the world where tree improvement is more advanced than in Alberta.

Following the start of the tree improvement program in Alberta in 1976, considerable time was spent on defining the long term nature, general direction and technical plans for the work program. Laboratory and greenhouse facilities for tree improvement were separately developed at the Pine Ridge Forest Nursery in 1979. These facilities were further expanded in 1984 in preparation for anticipated increases in the program work. Over this period cooperative working arrangements were also developed with the FMA forest industry, which currently participates in several projects and assists with the work.

At the commencement of the Canada-Alberta Forest Resource Development Agreement (C.A.F.R.D.A.) in 1985, the tree improvement program was in its ninth year of operation. Even though considerable progress had been made during this period, the work could still only be characterized to be in its early development stages. Furthermore, there were several projects on which work had been planned but could not be started because of lack of resources. It was considered to be highly beneficial to expand efforts of the ongoing tree improvement program and speed up work so that improvements in yield and timber quality could be realized from Alberta's forests starting at an earlier date. In recognition of these needs, the present project "Tree Improvement Applied Research and Technology Transfer" was approved by the C.A.F.R.D.A. Directorate for four years duration (1986/87 through 1989/90).

2.0 PROJECT OBJECTIVE

The objective of the project was to expand and accelerate work on the provincial genetics and tree improvement program in order to enhance yield, wood quality and pest resistance of future forest plantings in Alberta.

The tree improvement program of the Alberta Forest Service is an integrated research and development effort with province-wide scope. It addresses the needs of providing improved seed for reforestation and developing required scientific knowledge and technology for operational tree improvement. The purpose of C.A.F.R.D.A. tree improvement funding was to facilitate accomplishment of considerable amount of additional work in this area by supplementing A.F.S. resources.

3.0 PROGRESS REPORT AND ACCOMPLISHMENTS

The work being carried out as part of the C.A.F.R.D.A. tree improvement project consisted of enhancements to the provincial genetics and tree improvement program. For planning and reporting purposes this work was organized into five activity areas. These are:

1. Field selection and wood quality evaluations of superior trees
2. Research and demonstration trials
3. Survey and evaluation of rare and exceptional stands
4. Experimental areas development
5. Plant propagation, seed technology and technical support.

Progress report for these activities, covering the period April 1, 1986 through October 31, 1989, is presented in the following sections along with a brief explanation of the purpose of each activity and description of work accomplished. In selected instances, where data have already been summarized, research results are briefly presented to highlight interesting or noteworthy findings.

3.1 Field Selection of Superior Trees and Wood Quality Evaluation

The purpose of this activity was to locate and document superior trees to provide material for various genetic improvement projects. Once trees have been selected, scions are collected from these for grafting and establishing these in seed orchards. In addition wood samples are collected from individual trees to evaluate and document their wood quality. Finally, cones are collected from each to provide seed for genetic testing in field trials to identify true genetic worth of individual trees so that already established seed orchards can be rogued of inferior genetic stock to enhance genetic improvement of the seed produced.

The overall genetics and tree improvement program entails nine genetic improvement projects (five in white spruce and four in lodgepole pine). In addition a minor genetic improvement project was recently planned for Douglas-fir. Superior tree selection for many of these projects has been ongoing since 1976 and a large number of trees (approximately 1400) had already been selected prior to commencement of C.A.F.R.D.A.

As part of C.A.F.R.D.A. work, it was decided to carry out tree selections and related work for two genetic improvement projects. The first project deals with genetic improvement of white spruce for the Lac La Biche area which is identified as breeding region "E". The second project is the

newly established Douglas-fir genetic improvement project for the Bow/Crow Forest. Progress on these, along with a summary of results on wood quality analyses are discussed below.

3.1.1 White Spruce Project

During the report period a total of 69 superior white spruce trees were selected by cruising the Lac La Biche area. Nineteen of the trees were selected in 1986, thirty six in 1987 and fourteen in 1988. Three of the original selections were dropped due to inadequate superiority in some characteristics. Field data on all trees have been fully compiled and documentation reports completed. Scions collections and grafting of all 66 trees has also been completed. However, cones could only be collected from 22 of the selected trees which were found to produce a cone crop during the project duration. An illustration of a superior white spruce tree is shown in Figure 1a.

Wood quality analyses (relative density* and fibre length) were completed for wood samples collected from 67 of the original 69 of these trees. Results on these are presented in Table 1 and Figure 2. Overall average relative density of the trees examined was found to be 0.348, with a range from 0.302 to 0.395. Overall average fibre length for the 67 trees was found to be 3.01 mm with a range from 2.34 to 3.92. Variation of relative wood density within individual tree wood samples was also investigated by subdividing the samples in juvenile wood (rings 1-20), intermediate wood (rings 21-50) and mature wood (ring 51 onwards) portions. Overall average relative density for the three types of wood samples was found to be 0.342, 0.339 and 0.363 respectively. Similarly, average fibre length for the juvenile wood (rings 17-20) and mature wood (rings 47-50) was also investigated for all trees and found to be 2.57 mm and 3.31 mm respectively.

* Expressed as ratio of oven-dry weight and green volume of wood sample.

FIGURE 1 – ILLUSTRATIONS OF SUPERIOR WHITE SPRUCE AND DOUGLAS–FIR PARENT TREES

Figure 1a – Superior white spruce tree.

Figure 1b – Superior Douglas–fir tree.

Table 1. Average relative densities (RD) and fibre lengths (FL) for the 67 White Spruce Superior Tree selections from Lac La Biche and Athabasca

Ortet #	Average RD	Average FL (mm)	Ortet #	Average RD	Average FL (mm)
441	0.363	2.64	565	0.316	3.92
442	0.395	2.75	566	0.324	3.28
443	0.354	2.67	567	0.333	3.17
444	0.387	2.92	568	0.317	2.83
445	0.353	2.81	569	0.367	2.98
446	0.337	3.16	570	0.327	3.12
447	0.341	3.03	571	0.341	2.82
448	0.375	2.78	573	0.313	3.03
449	0.372	2.68	574	0.326	3.37
450	0.322	2.34	575	0.360	2.76
451	0.325	2.79	576	0.352	3.23
452	0.336	2.80	577	0.355	3.23
453	0.366	3.11	578	0.358	3.40
454	0.341	2.97	579	0.328	3.48
455	0.304	2.69	580	0.343	3.44
456	0.350	2.79	581	0.326	2.96
457	0.302	2.86	582	0.340	3.27
458	0.374	2.82	583	0.395	3.12
459	0.355	2.93	584	0.386	3.34
460	0.321	3.30	585	0.342	2.98
461	0.322	2.52	586	0.335	2.74
462	0.355	2.72	587	0.373	3.28
463	0.347	3.13	588	0.376	3.21
464	0.360	2.88	589	0.354	3.06
465	0.337	2.71	590	0.343	2.90
466	0.391	3.05	591	0.367	3.16
467	0.345	2.90	592	0.363	3.17
468	0.317	2.88	593	0.359	3.48
469	0.376	3.04	594	0.331	3.14
470	0.334	2.84	595	0.371	3.24
523	0.364	2.94	596	0.352	3.02
561	0.324	3.01	597	0.341	3.21
562	0.342	2.96	598	0.357	2.87
564	0.339	3.09			

FIGURE 2 – WOOD QUALITY CHARACTERISTICS OF WHITE SPRUCE

Figure 2a – Distribution of relative densities of 67 white spruce superior trees selected in Lac La Biche Forest.

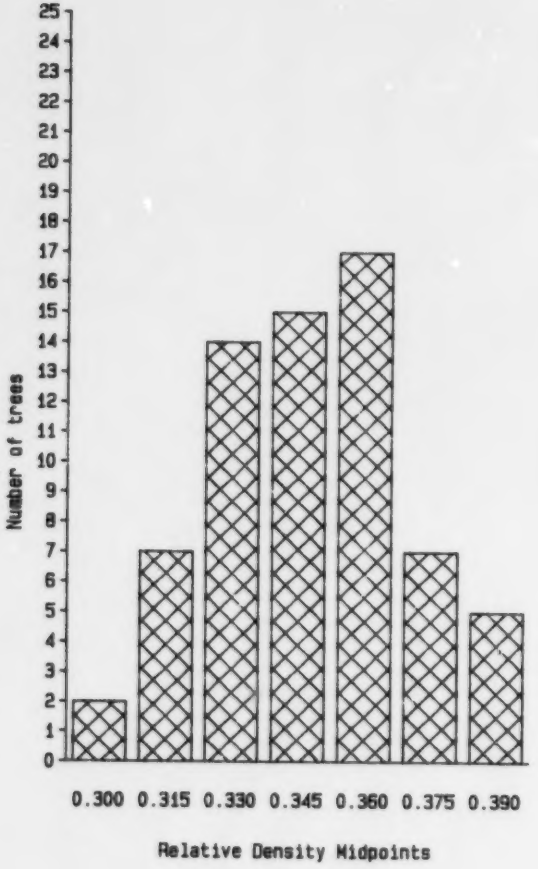
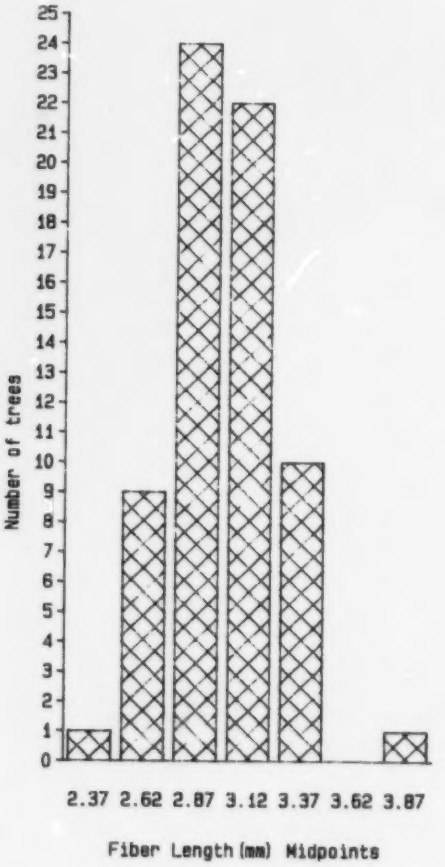


Figure 2b – Distribution of fiber lengths for 67 white spruce superior trees selected in Lac La Biche Forest.



3.1.2 Douglas-fir Project

A total of 32 superior Douglas-fir trees were selected by cruising promising Douglas-fir stands located in the Bow/Crow Forest. Field data on individual trees were compiled and related documentation completed. An illustration of a superior Douglas-fir tree is shown in Figure 1b.

Scions were collected from all 32 trees and grafting completed. Wood samples collected from these trees were also collected and analysed for relative wood density and fibre length. Results on these are presented in Table 2 and Figure 3. Overall average relative density of the 32 trees was found to be 0.430, with a range from 0.363 to 0.476. Overall fibre length for the 32 trees was found to be 2.44, with a range from 2.19 to 2.65.

Table 2. Average relative densities (RD) and Fibre lengths (FL) for 32 Douglas-fir selections from Bow/Crow

Ortet	Average RD	Average FL (mm)	Ortet #	Average RD	Average FL (mm)
531	0.416	2.63	629	0.416	2.49
532	0.416	2.65	630	0.476	2.57
533	0.405	2.51	631	0.461	2.34
534	0.396	2.46	632	0.438	2.33
535	0.406	2.31	633	0.423	2.31
536	0.451	2.50	634	0.383	2.19
537	0.445	2.39	635	0.474	2.41
538	0.386	2.56	636	0.428	2.51
539	0.401	2.32	637	0.452	2.32
540	0.432	2.43	638	0.473	2.33
557	0.418	2.35	640	0.447	2.64
558	0.389	2.40	641	0.473	2.47
559	0.405	2.48	642	0.438	2.54
560	0.452	2.50	643	0.416	2.65
601	0.426	2.22	644	0.422	2.38
602	0.472	2.21	645	0.439	2.55

FIGURE 3 – WOOD QUALITY CHARACTERISTICS OF DOUGLAS FIR

Figure 3a – Distribution of relative densities for 32 Douglas–Fir superior trees selected in Bow/Crow Forest

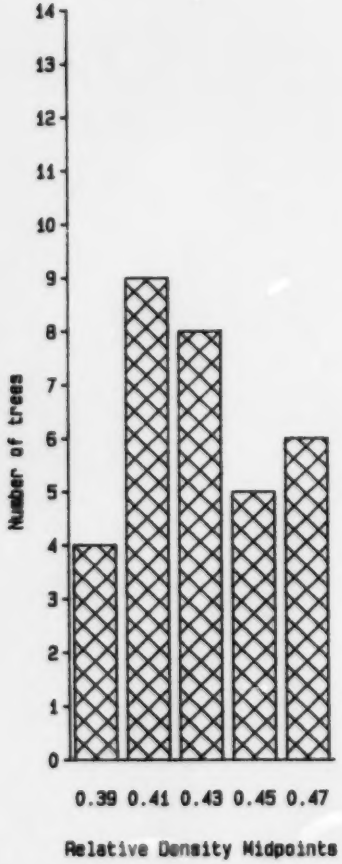
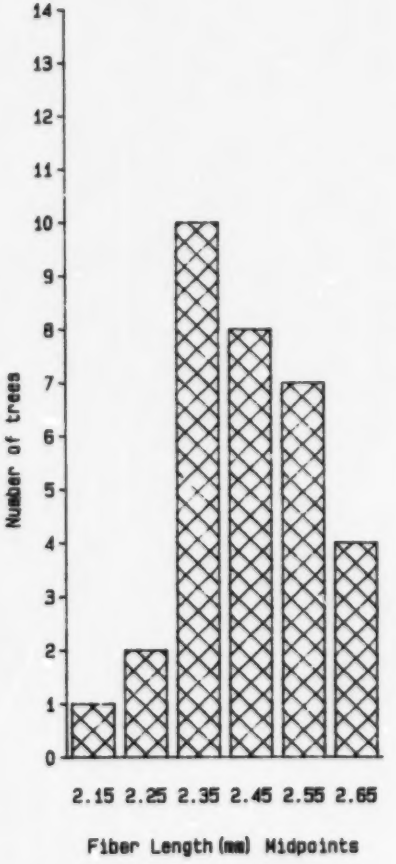


Figure 3b – Distribution of fiber lengths for 32 Douglas–Fir superior trees selected in Bow/Crow Forest



3.2 Research and Demonstration Trials

The purpose of this activity was to carry out field and laboratory research to develop new information and techniques for application in practical tree improvement in Alberta. In addition a small program was developed for field demonstrations to inform general public about the provincial tree improvement program. The work program under this activity is subdivided in four areas, which are: (1) species and provenance trials, (2) Genetic testing field trials, (3) seed production research trials, and (4) Demonstration trials. Progress and accomplishments on each of these are described below.

3.2.1 Species and Provenance Trials

The objective of species testing work is to identify more suitable species for reforestation in Alberta, in addition to white spruce and lodgepole pine which are the traditional reforestation species. The main objective of provenance research trials is to determine tolerance limits for geographic movement of seed sources of white spruce, black spruce, tamarack and lodgepole-jack pine. Prior to the commencement of C.A.F.R.D.A., a large number of research plantation had already been established throughout Alberta. These included an extensive series of white spruce provenance trials.

As part of C.A.F.R.D.A. tree improvement project, it was decided to establish a province-wide network of black spruce, tamarack, and lodgepole-jack pine plantings. Four field trials of lodgepole-jack pine had already been established in 1985, but the remaining trials were assigned to be completed as part of C.A.F.R.D.A. work.

During 1986 to 1989, a total of sixteen field trials were established and related documentation and establishment reports completed. Particulars of these trials are briefly described below:

TAMARACK PROVENANCE TRIALS (EXPERIMENT G136)

-- Seven field trials established at following locations:
  -- Pine Ridge Forest Nursery (Experiment G136A)
  -- Swartz Creek Experimental area in Edson Forest (Experiment G136B).
  -- Mitsue South Experimental Area in Slave Lake Forest (Experiment G136C).
  -- Hay River Experimental Area in Footner Lake Forest (Experiment G136D).
  -- Whitecourt Mountain Genetics Experimental Site in the Whitecourt Forest (G136E).
  -- Diamond Hills Genetics Experimental Site in Rocky/Clearwater Forest (G136F).
  -- Wandering River Genetics Experimental Site in Lac La Biche Forest (G136G).
-- Experimental design for the field trials consisted of randomized complete block design with 5 replications and 4-9 tree row plots. The number of seedlots among trials varies from 20-25, which includes 2 Siberian larch seedlots that were added for comparison purposes.
-- Planting spacing was 2.5 x 2.5 m at all locations except Pine Ridge Forest Nursery where planting spacing was 3 x 3 m.
-- Total number of trees planted at any location varied from 460-945 and the size of area outplanted ranged from 0.3 hectare to 0.8 hectare.
-- This completes the establishment phase of the series of province wide tamarack provenance trials to be established.

LODGEPOLE-JACK PINE SPECIES, 'OUTLIER' AND HYBRID POPULATIONS TEST (EXPERIMENT G 134)

-- Two field trials were established at the following locations in 1986:
  -- Hangingstone Experimental Area, Athabasca Forest (G134E).
  -- Mitsue South Experimental Area, Slave Lake Forest (G134F).
-- Experimental design for the field trials consisted of randomized complete block design with four replications and 5-6 tree row plots. Test material in each trial consisted of 34 seed sources of jack pine, lodgepole pine, jack-lodgepole pine natural hybrids collected from throughout Alberta as well as three seed sources of lodgepole pine from northeastern B.C.
-- Planting spacing was 2.5 x 2.5 m at both locations. The area outplanted in each trial was approximately 0.5 hectare.

Black Spruce Provenance Trials (G137)

-- Three field trials were established at the following locations in 1988 and 1989:
  -- Pine Ridge Forest Nursery (G137A).
  -- Whitecourt Mountain Genetics Experimental Site in Whitecourt Forest (G137B).
  -- Diamond Hills Genetics Site in Rocky/Clearwater Forest (G137C).
-- Experimental design for the field trials consisted of a randomized complete block design with five replications and nine tree row plots. Test material in each trial consisted of 20-21 seed sources.

-- Planting spacing was 2.5 m x 2.5 m in all trials except at Pine Ridge Forest Nursery where spacing was 3 m x 3 m.
-- Total number of trees planted at any one site varied from 700 to 990 and the size of the areas outplanted ranged from 0.4 ha to 0.6 ha.

Douglas-Fir Species Comparison Trials on Drought Prone Sites

Four field trials were established at the following locations:
-- Castle Experimental Area in the Bow/Crow Forest (G149A).
-- Porcupine Hills Experimental Site in the Bow/Crow Forest (G149B).
-- Bateman Creek Experimental Area in the Bow/Crow Forest (G149C).
-- Tershishner Creek Experimental Area in the Rocky/Clewarwater Forest (G149D).
-- Experimental Design for the field trials consisted of randomized complete block design with 5 replications and 10 tree row plots (2 rows of 5 trees each). Test material in each planting consisted of 4-5 Douglas-fir seedlots, 2 lodgepole seedlots, 2 white spruce seedlots and 1 western larch seedlot from British Columbia. Seven of the seedlots were "common" to each site and 2 or 3 seedlots were "local" and found only at certain sites.

Douglas-Fir Species Comparison Trials on Drought Prone Sites (Continued)

-- Planting spacing was 2.5 m x 2.5 m at all sites.
-- Total number of trees varied from 450-500 trees. The size of each planting varied from 0.25 hectares to 0.31 hectares.

Once established, work carried out for species and provenance trials, as part of C.A.F.R.D.A. project, also included maintaining and tending the plantings.

3.2.2 Genetic Testing Field Trials

The objective of genetic testing field trials was to evaluate genetic worth of open-pollinated seedlots or progenies collected from superior trees selected in the wild forests and propagated for various genetic improvement projects. Based on periodic results of these trials, roguings are carried out in already established seed orchards. These roguings progressively cull out inferior genetic stock and increase the level of genetic improvement that can be realized from seed orchards.

Prior to commencement of C.A.F.R.D.A., eight large genetic test plantations of lodgepole pine had already been established in west central Alberta. Extension of this work to white spruce was made possible by C.A.F.R.D.A. funding. Four field trials were established as part of this work. These trials correspond to genetic improvement of white spruce for breeding region "D". Each trial contained open pollinated progenies or half-sib seedlots from 144-150 superior trees selected in region "D" area during 1976-1979. Nursery stock production for these trials was started in 1983, prior to commencement of C.A.F.R.D.A. However the field outplantings of these trials was carried out in 1986 as part of C.A.F.R.D.A. work, and related documentation and establishment reports completed. Some further details of these trials are given below:

-- Title of the trials is: Half-sib family testing for breeding region "D" (Experiment G132).
-- Trials are established at following locations:

    -- Calling Lake Experimental Area in the Lac La Biche Forest (Experiment G132A).
    -- Mitsue South Experimental Area in the Slave Lake Forest (Experiment G132B).
    -- Red Earth Experimental Area in the Slave Lake Forest (Experiment G132C).
    -- Carson Lake Experimental Area in the Whitecourt Forest (Experiment G132D)

-- Experimental design for the field trials consists of randomized complete block design with six replications and five or six tree row plots. Number of seedlots in individual trials varies from 146-150.
-- Planting spacing was 2.5 x 2.5 m at all locations. The area outplanted in each trial varied from 2.8-3.5 hectares.

Following establishment maintenance tending was carried out on all plantings during 1986 - 1988 with the assistance of C.A.F.R.D.A. funding.

3.2.3 Seed Production Research Trials

Prior to the commencement of C.A.F.R.D.A., several seed production research trials were established by the Alberta Forest Service to develop much needed technical information for seed orchard planning, and to develop practical prescriptions to enhance flowering, seed production and seed quality of white spruce and lodgepole pine. With the start of C.A.F.R.D.A. tree improvement project in 1986, three studies were assigned to be continued as part of this project. This permitted more intensive laboratory and field evaluations and analyses of the studies, which would not have been possible otherwise. The three studies are briefly discussed below, along with highlights of results.

STUDY 1: SUPPLEMENTAL POLLINATION OF LODGEPOLE PINE (EXPERIMENT G222)

This study was established in 1985 in a research seed orchard located at Pine Ridge Forest Nursery. The objective was to evaluate effectiveness of supplemental or booster pollination technique, in increasing seed yield of lodgepole pine in comparison to ordinary wind pollination. Eighteen six-year-old lodgepole pine trees were divided into two groups of nine trees each. One group was designated as 'control' and received wind borne pollen only to fertilize seed cone flowers. In addition to wind pollination, the second group of trees was also supplementally pollinated by hand with fresh pollen.

In 1986, as part of C.A.F.R.D.A. work, cones were collected from individual trees and separately extracted. Data were collected on (1) numbe of seeds per cone, (2) 1000 seed weight, and (3) seed germination. It was r found that supplemental pollination substantially increased mean number of seeds per cone. Summary of results on the three variables studied is presented in Table 3.

TABLE 3
Seed Production and Seed Quality of
Lodgepole Pine Supplemental Pollination Study

Treatment Group	No. of Seeds Per Cone Mean + S.E.	1000-Seed Weight (g) Mean + S.E.	Germination (%) Mean + S.E.
Control	15.9 ± 3.2	4.60 ± .15	96.7 ± 0.9
Supplemental pollination	24.7 ± 2.8	4.27 ± .22	94.5 ± 1.0

In 1988-89 the study was repeated using different study trees to verify trends observed in the 1985-86 study.

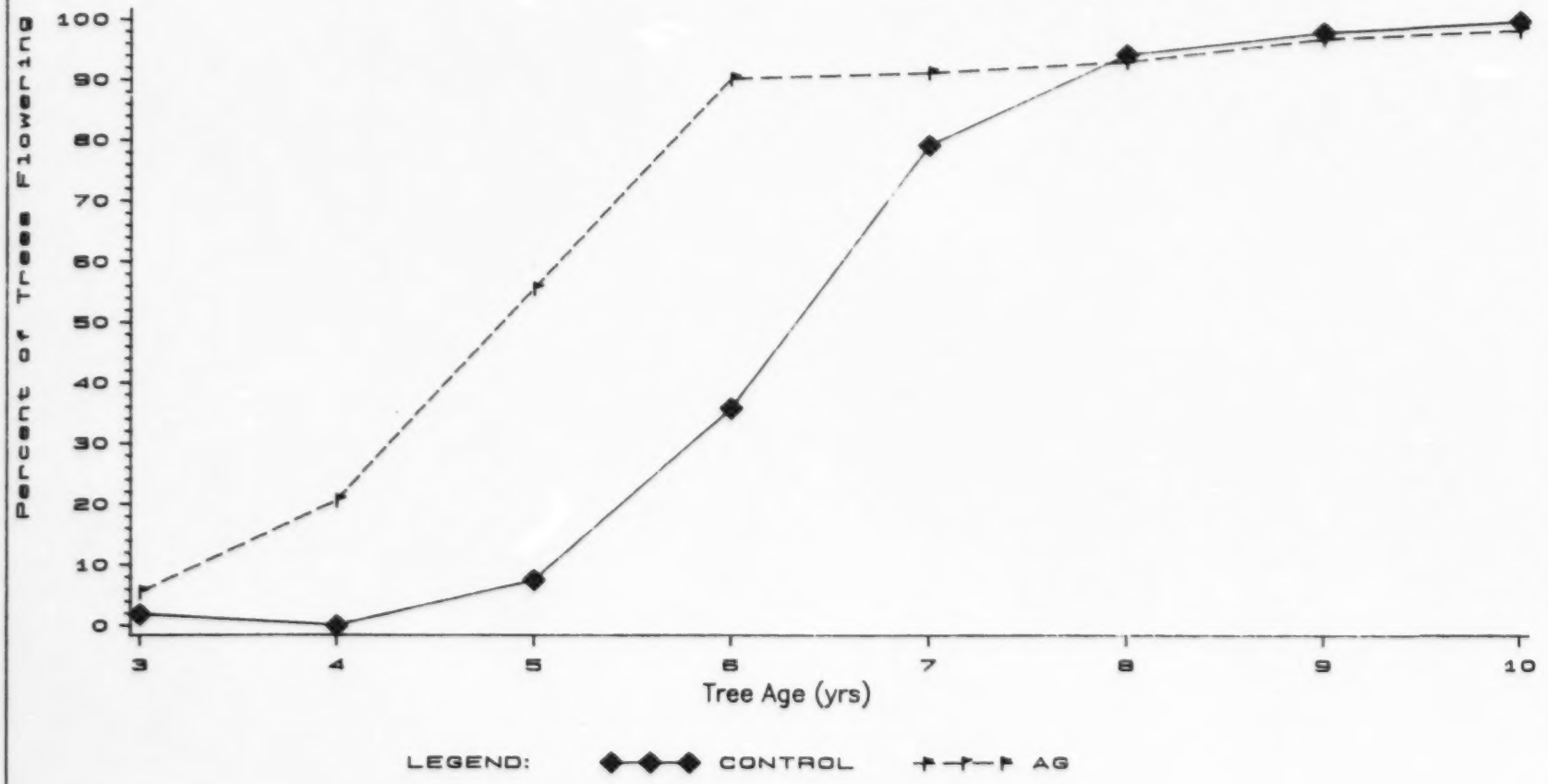
STUDY 2: FLOWERING AND SEED PRODUCTION OF WHITE SPRUCE AND LODGEPOLE PINE IN "ACCELERATED GROWTH" SEEDLING SEED ORCHARD (EXPERIMENT G124)

In 1980 a study was started to learn about changes in flowering and seed production of white spruce and lodgepole, with increasing age in a seedling seed orchard established at Pine Ridge Forest Nursery. In addition, the study was also designed to evalauate the flowering and seed production response of lodgepole pine and white spruce seedlings that received an "accelerated growth" (AG) seedling rearing treatment. The AG treatment consisted of a continuous photoperiod provided by a lighting system comprised of a combination of incandescent and high pressure sodium lamps and heavier application of nutrients for eight months in the greenhouse. Conventionally grown seedlings of the same seedlots were outplanted in a plantation adjacent to the "AG" planting. Each year data was recorded from individual trees on the following traits: number of female strobili produced, number of male strobilus clusters produced, cone size and volume, seed yield and seed germination.

Starting in 1986, work on this study was transferred to C.A.F.R.D.A. project. At this time the study trees were seven years old and the lodgepole pine started to produce sizeable flower and cone crops. Considerable extra resources were needed to carry out the required investigations. As part of the C.A.F.R.D.A. work, data were collected for four cone crop years (1986 to 1989). Interesting and useful information started to emerge to assist in seed orchard planning as part of the Alberta tree improvement program. In 1989 a ten year assessment of the two plantings was completed. Early growth and development data indicates that the "AG" treatment is effective in promoting flowering at an earlier age and in reducing the time required to attain commercial levels of seed production in lodgepole pine seed orchards. Flowering had begun at age 3 years. Both male and female flowering was observed. Significant cone production began at age 8 years. The same flowering trends were observed in the conventionally grown lodgepole pine, but

FIGURE 4 – FLOWERING SUMMARY OF LODGEPOLE PINE: PERCENTAGE OF TREES FLOWERING

Percentage of trees showing flowering in
in two treatment groups (AG vs control)* at different ages.



*AG = planting stock grown under accelerated growth regime.
*control = planting stock grown under "standard" growing regime
Note: only study years 7 – 10 work is funded by C.A.F.R.D.A.

FIGURE 5 – FLOWERING SUMMARY OF LODGEPOLE PINE: MALE AND FEMALE STROBILUS PRODUCTION

Figure 5a – Mean number of female strobili produced per tree in two treatment groups (AG vs. control)* at different ages

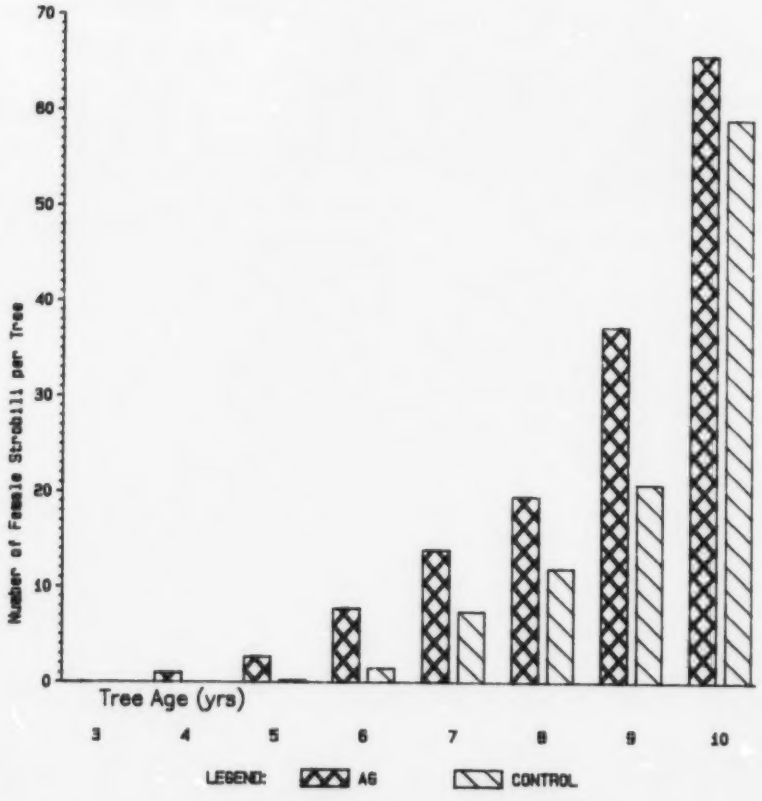
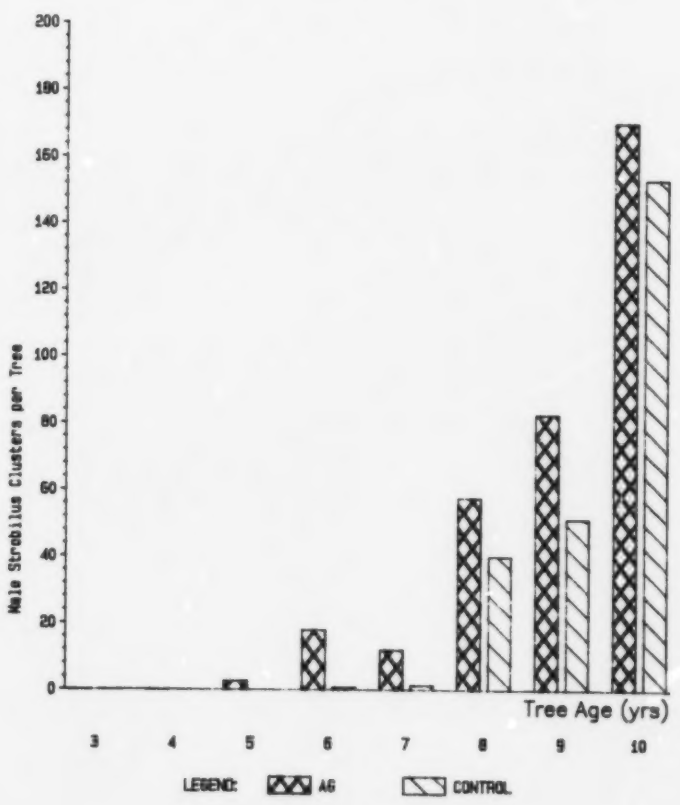


Figure 5b – Mean number of male strobilus clusters produced per tree in two treatment groups (AG vs. control)* at different ages



*AG = planting stock grown under accelerated growth regime.
*control = planting stock grown under "standard" growing regime
Note: only study years 7 – 10 work is funded by C.A.F.R.D.A.

two years later. At age ten years the flowering and growth in the two treatments was comparable. The "AG" lodgepole pine produced an average of 66 female strobili and 170 male strobili clusters. This compares to 59 female strobili and 153 male strobili clusters observed in the conventionally grown pine. Seed yield and seed quality compares to that of mature lodgepole pine and lodgepole pine-jack pine hybrid stands in Alberta. Results from the white spruce plantings indicates that the "AG" treatment promotes significantly more vigorous growth and flowering at an earlier age than that observed in conventionally grown white spruce. Eight percent of the "AG" white spruce produced flowers at age five years. The conventionally grown spruce has not began to flower to date. Some preliminary results on time trends in flowering of lodgepole pine and effectiveness of "AG" treatment in enhancing flowering in this species are shown in Figures 4 and 5.

STUDY 3: EARLY FLOWERING AND SEED PRODUCTION OF WHITE SPRUCE GRAFTS AT FOUR LOCATIONS IN ALBERTA AND BRITISH COLUMBIA (EXPERIMENT G125)

This study was started in 1979 out of a concern to find out the best location for establishing white spruce seed orchards as part of Alberta tree improvement progam, and to learn about flowering and seed production of the species in clonal seed orchard situation. The study involved yearly monitoring of flowering, cone production, seed yield and seed quality of white spruce grafts of northern Alberta origin established at four climatically diverse locations in Alberta and British Columbia. Grafts were made in 1979 and plantings were established in 1981 and 1982. The outplantings contained three or four grafts of 12-17 clones. Outplanting locations were: (1) a 'local' northern Alberta site at Grande Prairie, (2) a central Alberta site at Smoky Lake, (3) a southern Alberta site at Brooks, and (4) a south central British Columbia site at Vernon which is known for its warm climate.

Starting in 1986, work on this study was transferred to the C.A.F.R.D.A. project. At this time grafts were seven years old and had started to flower profusely. This allowed detailed investigations on cone and seed aspects of this study to commence. Field and laboratory investigations have now been completed for cone crop years 1986 and 1989. Each year information was compiled on individual grafts at each location for the following traits: number of male and female strobili produced, number of cones produced, seed yield, seed soundness and seed germination. Experimental data have been partially analysed and some selected results are presented in Tables 4 and 5 to illustrate the scope and significance of this work.

The results have provided insight into the variation in flowering, cone production, seed yield and seed quality of white spruce clones from year to year and according to locations. Based on these findings, it can be concluded that significant cone production from white spruce clonal seed orchards in Alberta can be expected seven years following grafting. The study also alleviated earlier concerns with regard to the suitability of Pine Ridge Forest Nursery (Smoky Lake) and Grande Prairie site for establishing seed orchards.

Table 4. Summary of results on Flowering of white spruce grafts during 1983 - 1989 at four locations in Alberta and British Columbia

Location	Average No. of Grafts Flowering per Year (%)	Mean No. of Strobili/Graft/Year	
		Female	Male
Vernon, B.C.	68.6	14.6	39.2
Brooks, Alberta	56.5	15.7	48.1
Smoky Lake, Alberta	36.5	14.0	12.7
Grande Prairie Alberta	50.9	20.0	27.8

Note: Only 1986-1989 work is covered by C.A.F.R.D.A.

Table 5. Cone production and seed characteristics of white spruce grafts in 1986 cone crop year at Grande Prairie, Alberta

Clone Number	No. Living Grafts	Mean No. Cones/Graft	Mean No. Seeds/Cone	Mean Filled Seed (%)	Mean Germination (%)
X73	4	13.0	9.3	90.0	75.0
X76	2	5.5	0	--	--
X78	2	24.0	8.3	94.5	84.0
X80	4	157.8	2.6	95.1	91.1
X81	4	37.8	4.1	92.1	86.6
X82	3	109.7	6.7	96.6	90.8
X83	3	50.0	8.9	97.5	93.3
X84	1	183.0	5.7	96.0	85.5
X86	2	93.5	6.3	98.5	94.7
X90	2	53.5	10.7	93.2	87.7
X91	3	88.0	3.4	95.1	88.0
X92	4	47.3	2.5	83.2	87.1
Overall Mean	-	71.9	5.7	93.8	87.6

3.2.4 Demonstration Trials

Five demonstration plantings were established in 1988 and 1989 at the "Genetics and Future Reforestation" site that was developed as part of the Jumpingpound Demonstration Forest. The Jumpingpound Demonstration Forest is a separately funded C.A.F.R.D.A. project.

The overall objective of the "Genetics and Future Reforestation" demonstration plantings is to introduce the general public to the provincial genetics and tree improvement program and explain how it contributes to improving the yield and wood quality of Alberta's future forests. The experimental plantings demonstrate selected aspects of genetics and tree improvement work. The plantings and concepts are explained through the use of interpretative signs installed along a self-guided trail through the site.

Details of the trials are given below:

Native Species Arboretum

-- Specific objective of the arboretum is to familarize the general public with a variety of native Alberta tree species and illustrate how the different species vary in growth, hardiness, and suitability of wood for forest products.
-- Consists of 13 coniferous and 3 deciduous tree species.
-- Experimental design is an unreplicated planting with 14 tree plots (2 rows of 7 trees).
-- Planting spacing was 3 m x 3 m.

-- Total number of trees outplanted is 224. Size of the arboretum is 0.2 hectares.

Demonstration Spruce Seed Source Planting and
Demonstration Lodgepole Pine Seed Source Planting

-- Specific objective of the seed source plantings is to illustrate how geographic origin of seed sources can affect the performance of reforestation plantings, and what the practical implications of seed source has on forestry.
-- Each planting consists of 5 seed sources which range from the southern to northern extremes of the species native range.
-- Experimental design is an unreplicated planting with 16 tree plots (2 rows of 8 trees).
-- Planting spacing was 3 m x 3 m.
-- Total number of trees outplanted is 80 per species. A total of 0.15 hectares was used to establish the two plantings.

Clonal Variation in Trembling Aspen

-- Objective of the planting is to familarize the public with the concept of cloning.
-- Planting consists of 3 clones of trembling aspen. Clones were selected for their stem form. Two of the clones had crooked stems and the third clone had straight stems.
-- Experimental design is an unreplicated planting with 21 tree plots (3 rows of 7 trees).
-- Planting spacing is 3 m x 3 m.
-- Total of 63 trees were planted. A total of 0.06 hectares was used to establish the planting.

Clonal Douglas Fir Seed Orchard

-- Design and layout of the Douglas fir grafted seed orchard was completed.
-- Experimental design for the seed orchard consists of a randomized complete block design with 12 replications and single tree plots.
-- Each replication contains 31 clones. Phase I planting was completed in 1989. It consists of 180 grafts from 15 selected Douglas-fir superior trees. The remaining 192 grafts from 16 clones will be outplanted in 1990.
-- Planting spacing is 3 m x 4 m. Once remaining planting of the orchard is completed in 1990, the total area covered by the orchard will be about 0.5 ha.

3.3 Survey and Evaluation of Rare and Exceptional Stands

The purpose of this activity was to survey the province for forest stands of rare and exceptional nature. Once these stands were identified, they were then to be documented and designated as gene pool reserves for long term conservation of genetic resources of species of forestry importance in Alberta. This activity was a new function of the provincial genetics and tree improvement program and was commenced with the start of C.A.F.R.D.A. tree improvement project in 1986. Progress of work accomplished is described below.

3.3.1 Methodology

The project was started in the Slave Lake Forest in September 1986. It was completed in March 1988, with all six Ranger Districts having been surveyed. An office survey for candidate stands was conducted for each of the Ranger Districts from AFFORISM data supplied by Timber Management Branch and suggestions by Forest field staff. From this, 380 stands were identified and visually inspected from the air or on the ground. A short list was then compiled and 28 of the stands were chosen for a detailed field assessment. The short list consisted of eighteen white spruce stands, two tamarack stands, five black spruce stands, two lodgepole pine stands and one jack pine stand. The actual survey process for cruising candidate stands was quite intensive. Part of the purpose of the work in the Slave Lake Forest was to "fine tune" the evaluation criteria for each of the parameters measured in the ground survey. Fifty five plots were estabished on an equally spaced sampling grid and data relating to composition, stocking, basal area/hectare, ages, crown form, straightness and branching characteristics were measured at each plot.

3.3.2 Analysis of Stand Data

The data for each stand was then evaluated using a number of statistics. Criteria relating to overall stand composition, ratio of volume in dominant and co-dominant trees to overall stand volume, height-age ratios were all treated as having a minimal acceptance level. Using these criteria seven stands (5 white spruce, 1 tamarack and 1 black spruce) were assessed as having exceptional characteristics . They are described in Table 6.

3.3.3 Exceptional Stands

Land reservations have been put in place to protect the seven stands designated as exceptional.

3.3.4 Future Plans

A significant part of the work in the Slave Lake Forest consisted of refining the methodology and putting in place a complete and working survey system for identifying rare and exceptional stands in Alberta. This was accomplished and the project can now be extended to the nine remaining Forests depending upon the availability of future resources.

Table 6. Location and Description of Seven "Exceptional" Stands in Slave Lake Forest

STAND	GEOGRAPHIC LOCATION		DESCRIPTION
	Latitude	Longitude	
SSw-01	55° 24'	114° 48'	27.4 ha. 100% white spruce stocking. Good height/age and form characteristics. Exceptional because of its unique stocking and age (99 Yrs.).
SSw-08	56° 05'	113° 46'	57.5 ha. Age under 100 years. Excellent height, diameter. Best branch angle score of all stands cruised.
SSw-10	55° 00'	114° 40'	33 ha. Young white spruce stand. Very high stocking levels. 20 m tall at age 50.
SSw-12	56° 35'	116° 05'	50.9 ha. 75% white spruce stocking. Excellent height/age ratio.
SSw-14	56° 35'	115° 35'	27.4 ha. 86 yrs old. Excellent height/ age ratio. Good diameter growth over last 20 years.
SSb-02	54° 58'	115° 14'	4.8 ha. 90% black spruce stocking. Age 49 years. Height/age ratio over 25 cm/yr.
SLt-02	55° 23'	115° 20'	9.7 ha. 92% tamarack. Age 57 years. Good height/age ratio and superior stem form.

NOTE: Reservations have been placed on all of these stands.

3.4 Experimental Areas Development

The purpose of this activity was to develop and provide additional experimental areas for establishment of seed orchards, research plantings and germplasm banks for the expanded provincial genetics and tree improvement program. Prior to the commencement of C.A.F.R.D.A. Tree Improvement project, a network of 22 genetics and tree improvemental experimental areas, spread throughout the province, was already developed. This network was further expanded to provide additional sites for current and future needs of the provincial tree improvement program.

Seven new experimental areas developments were undertaken with the assistance of C.A.F.R.D.A. funding. A brief description of the location of each site and site work completed with C.A.F.R.D.A. funding is given below.

3.4.1 Wandering River Experimental Area

- The site is located in the Lac La Biche Forest adjoining Wandering River Ranger District.
- Geographic location is:
  - Latitude: 55° 30' N
  - Longitude: 112° 30' W
  - Elevation: 579 m
  - Legal description is SE 2-72-17-W4M
- Net area developed is approximately 12 hectares.
- Work carried out on the site was as follows:
  - Slash piles burned and disposed of on already partially developed site.
  - Land breaking, rock picking and root raking completed.
  - Site was plowed, fertilized and seeded with fall rye, discing fall rye was done in 1987 and site was seeded to grass.
  - Trickle irrigation was installed on a part of the site.
  - The site was made fully ready for planting in spring 1989.

3.4.2 Whitecourt Mountain Experimental Area

- The site is located in the Whitecourt Forest near the town of Whitecourt.
- Geographic location is:
  - Latitude: 54° 04' N
  - Longitude: 115° 47' W
  - Elevation: 800 m
  - Legal description is SE 36-58-13-W5M

3.4.2 Whitecourt Mountain Experimental Area (Continued)

- -- Net area developed is approximately 11 hectares.
- -- Work carried out on the site was as follows:
  - -- Slash piles repiled and reburned on already partially developed site.
  - -- Site rotovated, disced twice and seeded to grass.
  - -- Access trail and dugout was put in.
  - -- Chain link fence installed to protect site from trespass and wildlife damage.
- -- The site was made fully ready for planting in 1989.

3.4.3 Diamond Hill Experimental Area

- -- The site is located in the Rocky/Clearwater Forest in Diamond Hill reserve.
- -- Geographic location is:
  - -- Latitude: 52° 37' N
  - -- Longitude: 115° 05' W
  - -- Elevation: 991 m
  - -- Legal description is pts. Sec 16-42-8-W5M
- -- Net area developed is approximately 10 hectares.
- -- Work carried out on the site was as follows:
  - -- Repile and reburn slash on already partially developed site.
  - -- Chain link fence installed to protect site from trespass and wildlife damage.
- -- The site was made fully ready for planting in Spring 1989.

3.4.4 Tershishner Creek Experimental Area

- -- The site is located in the Rocky/Clearwater Forest near Nordegg.
- -- Geographic location is:
  - -- Latitude: 52° 21' N
  - -- Longitude: 116° 23' W
  - -- Elevation: 1500 m
  - -- Legal description is LS 1-10-39-17-W5M
- -- Net area developed is 2.5 hectares.
- -- Work carried out on the site was as follows:
  - -- Site clearing, slash piling and burning and reburning slash piles.
  - -- Site disced and redisced.
  - -- Chain link fence installed to protect site from trespass and wildlife damage.
- -- The site was made fully ready for planting in Summer 1989.

3.4.5 Bateman Creek Experimental Area

- The site is located in the Bow/Crow Forest near the Jumpingpound Demonstration Forest site.
- Geographic location is:
  - Latitude: 51° 03' N
  - Longitude: 114° 49' W
  - Elevation: 1448 m
  - Legal description is SE 1/4 LS 14-24-6-W5M
- Net area developed is approximately two hectares.
- Work carried out on the site was as follows:
  - Slash piling and burning slash piles on already cleared site.
  - Site disced and redisced.
  - Barbed wire fence installed to protect site from cattle trespass.
- The site was made fully ready for planting in Summer 1988.

3.4.6 Porcupine Hills Experimental Area

- The site is located in the Bow/Crow Forest in Porcupine Hills reserve.
- Geographic location is:
  - Latitude: 49° 51' N
  - Longitude: 114° 20' W
  - Elevation: 1830 m
  - Legal description is E 1/2 LS 14-36-10-1-W5M
- Net area developed is approximately 1.5 hectares.
- Work carried out on the site was as follows:
  - Clearing site, slash piling and burning slash piles.
  - Land breaking, stumping, discing and rediscing site.
  - Installation of barbed wire fence to protect site from cattle trespass.
- The site was made fully ready for planting commencing Summer 1988.

3.4.7 Castle River Experimental Area

- The site is located in the Bow/Crow Forest near Blairmore, adjacent to an already established genetics and tree improvement experimental area.
- Geogrpahic location is:
  - Latitude: 49° 20' N
  - Longitude: 114° 20' W
  - Elevation: 1350 m
  - Legal description is LS 1-22-5-3-W5M

3.4.7 Castle River Experimental Area (Continued)

- -- Net area being developed is 1.8 hectares.
- -- Work carried out on the site was as follows:
  - -- Clearing site, slash piling and burning slash piles.
  - -- Land breaking, discing and rediscing site.
  - -- Installation of barbed wire fence to protect site from cattle trespass.
- -- The site was made fully ready for planting commencing Summer 1988.

3.4.8 Alder Flats Experimental Area

- -- The site is located in the Rocky/Clearwater Forest.
- -- Geographic location is:
  - -- Latitude: 52° 47' N
  - -- Longitude: 114° 52' W
  - -- Elevation: 978 m
  - -- Legal description is LSD 1-25-44-7-W5.
- -- Net area developed is 10 hectares.
- -- Work carried out on the site consisted of clearing site, slash piling and burning slash piles in 1988.
- -- The site development is left incomplete.

3.4.9 Kinosis Lake Experimental Area

- -- The site is located in the Lac La Biche Forest.
- -- Geographic location in:
  - -- Latitude: 56° 15' N
  - -- Longitude: 110° 58' W
  - -- Elevation: 470 m
  - -- Legal description is parts of LSD 5, 6, 11, 12, 13, 14 25-84-7-W4M.
- -- Net area being developed is 10 hectares.
- -- Work carried out on the site consisted of clearing site and piling slash in 1988.
- -- The site development is left incomplete.

In addition to the new experimental areas developments, C.A.F.R.D.A. funds were also used for minor site improvement work on existing genetics and tree improvement experimental areas. The work carried out in this regard consisted of fence repairs and backfilling along fence lines at Fox Creek and Carson Lake Experimental Areas and minor site improvements and maintenance activities at various other sites.

3.5 Plant Propagation, Seed Technology and Technical Support

The purpose of this activity was to carry out an increased production program at Genetics Section, Pine Ridge Forest Nursery in support of the expanded portion of genetics and tree improvement program due to C.A.F.R.D.A. In addition, increased technical assistance and EDP support was provided as per requirements of the expanded program. The work completed during the report period was as follows:

- -- 1,655 white spruce and 605 Douglas-fir grafts were made.
- -- 6,000 white spruce and 650 Douglas-fir rootstock trees were potted for grafting program.
- -- Tending and maintenance was carried out on new grafts as well as on grafts established in holding areas and clone banks.
- -- 594 seedlots were extracted and processed: 592 seedlots were germination tested.
- -- Wood specific gravity and fibre length analysis were completed on wood samples collected from 32 Douglas-fir and 67 white spruce trees.

To meet data management and statistical analyses needs of the expanded genetics and tree improvement program a micro-computer with supporting hardware and software were acquired with C.A.F.R.D.A. funds. In addition to this, two other micro-computers were partially funded through the C.A.F.R.D.A.

Several pieces of specialized equipment were purchased to assist the expanded genetics program at Pine Ridge Forest Nursery. These include:

- -- 30" hydraulic tree spade to be used to rogue seed orchards and consolidate remaining trees. Also to create artificial drought stress in flowering and seed production studies.
- -- biophenometer (growing degree day and chilling hour accumulator) to be used to develop the relationships between growing degree days and flowering and chilling hours and plant dormancy.

4.0 CONCLUSION

The Canada/Alberta Forest Resource Development Agreement funding during the project duration assisted in accomplishment of substantial amount of additional work on the provincial genetics and tree improvement program than would have been possible with A.F.S. regular budgets. This has facilitated more rapid development of improved strains of tree seed and seed orchards to mass produce genetically superior seed for reforestation. Research efforts could also be intensified to develop much needed new information and technology for practical tree improvement in Alberta. It also made possible establishment of several field demonstrations to explain tree improvement program to general public. All this has greatly assisted in Alberta's efforts to enhance timber yield and quality of the future forest and to realize these benefits starting at an earlier date.